Assessment of Terrestrial Carbon Sequestration Options within a Market for Greenhouse Gas Emissions

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Overview

- Motivation
- Agricultural Sector Model (ASMGHG)
  - Soil sequestration
  - Afforestation
  - Biofuel offsets
- Energy System in Second Generation Model
  - Compare marginal cost of mitigation among all options
  - Carbon capture and disposal from electricity generation
- Hypothetical Emissions Scenarios
  - Net carbon emissions remain at year 2000 levels
  - Hotelling carbon price path
- Conclusions

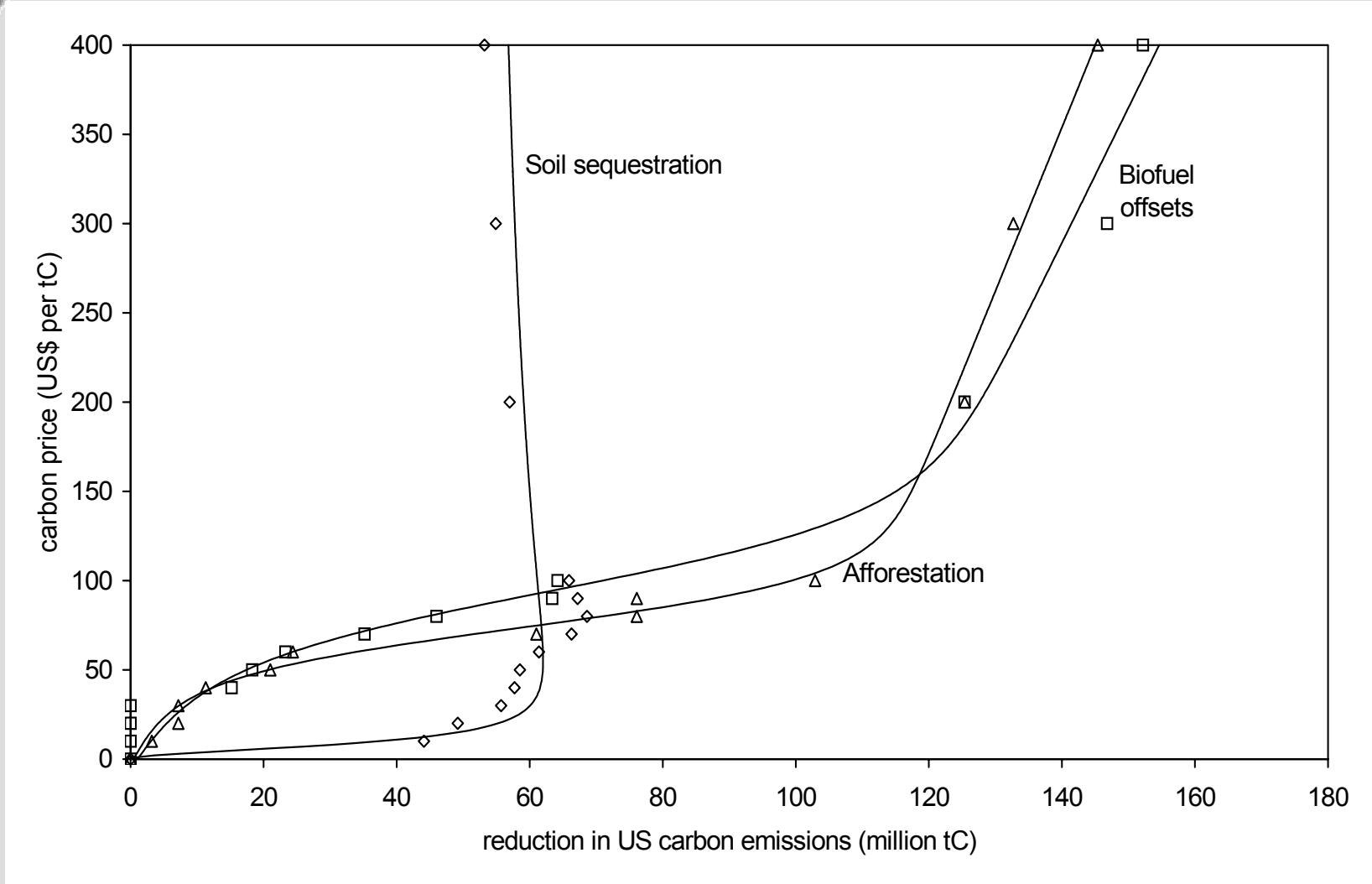
Motivation

- Analysis of greenhouse gas mitigation options within a national economic model
  - No single model can simulate all activities and processes
  - Typical analysis uses top-down economic model to simulate response of energy system to a carbon price
  - Process models of agriculture and forestry can inform economic models of other mitigation options
- Include options from agriculture and forestry
  - Soil sequestration
  - Afforestation
  - Biofuel offsets
- Sponsored by program to enhance Carbon Sequestration in Terrestrial Ecosystems (CSiTE), Office of Science, U.S. Department of Energy

Agricultural Sector Model

- Model characteristics
  - Nonlinear programming model of U.S. agricultural sector
  - 22 traditional crops, 3 biofuel crops, 29 animal products, 63 U.S. regions
- Mitigation options
  - Soil sequestration: carbon stored in agricultural soils related to cropping and tillage practices
  - Afforestation: expanded forest land area relative to 1990 base
  - Biofuel offsets: net reduction in carbon emissions by using biomass-based fuels instead of fossil fuels
- Interactions among options
  - Competition for land
  - Backward-bending supply curve for soil sequestration component

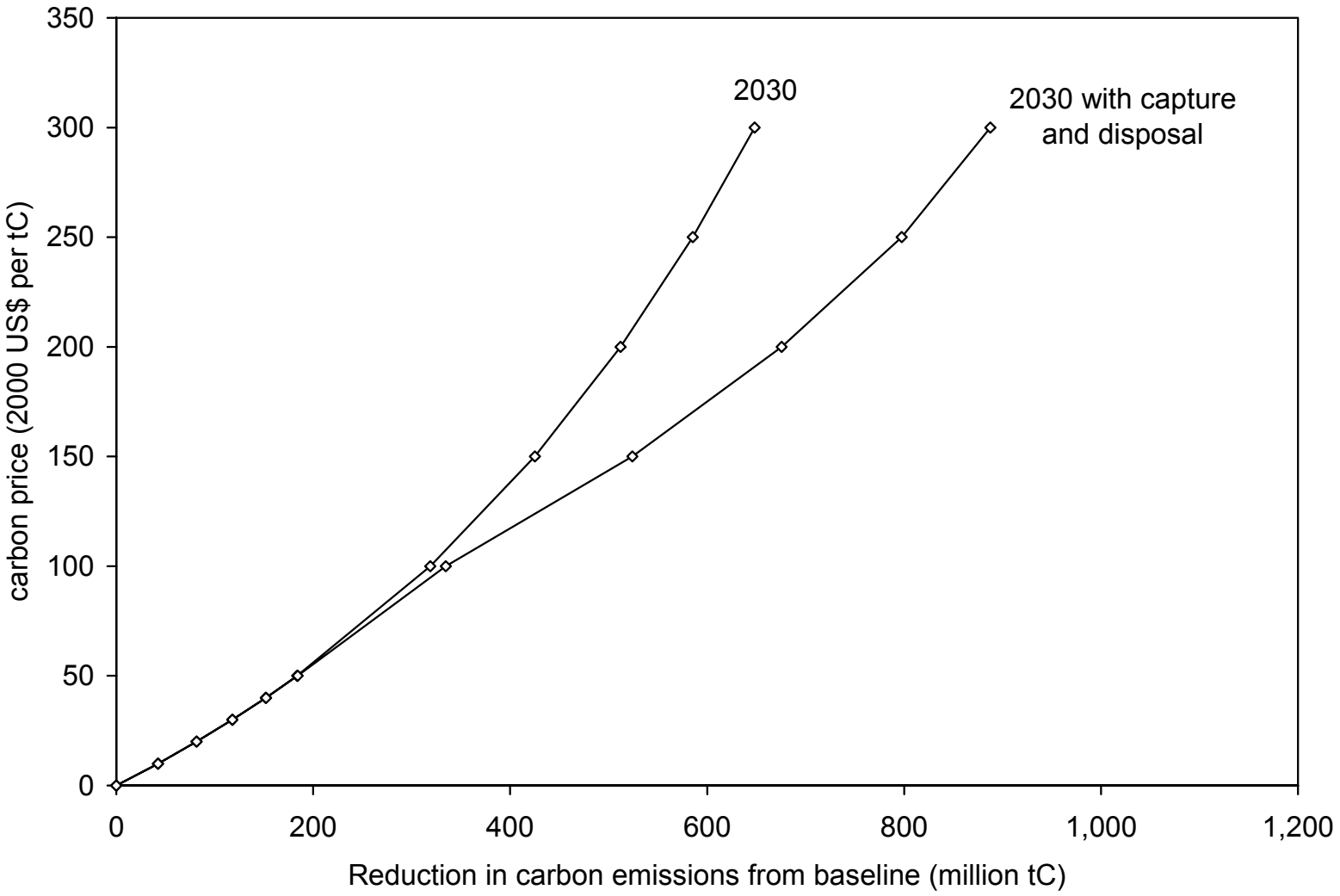
Reduction in carbon emissions from three activities simulated in the Agricultural Sector Model



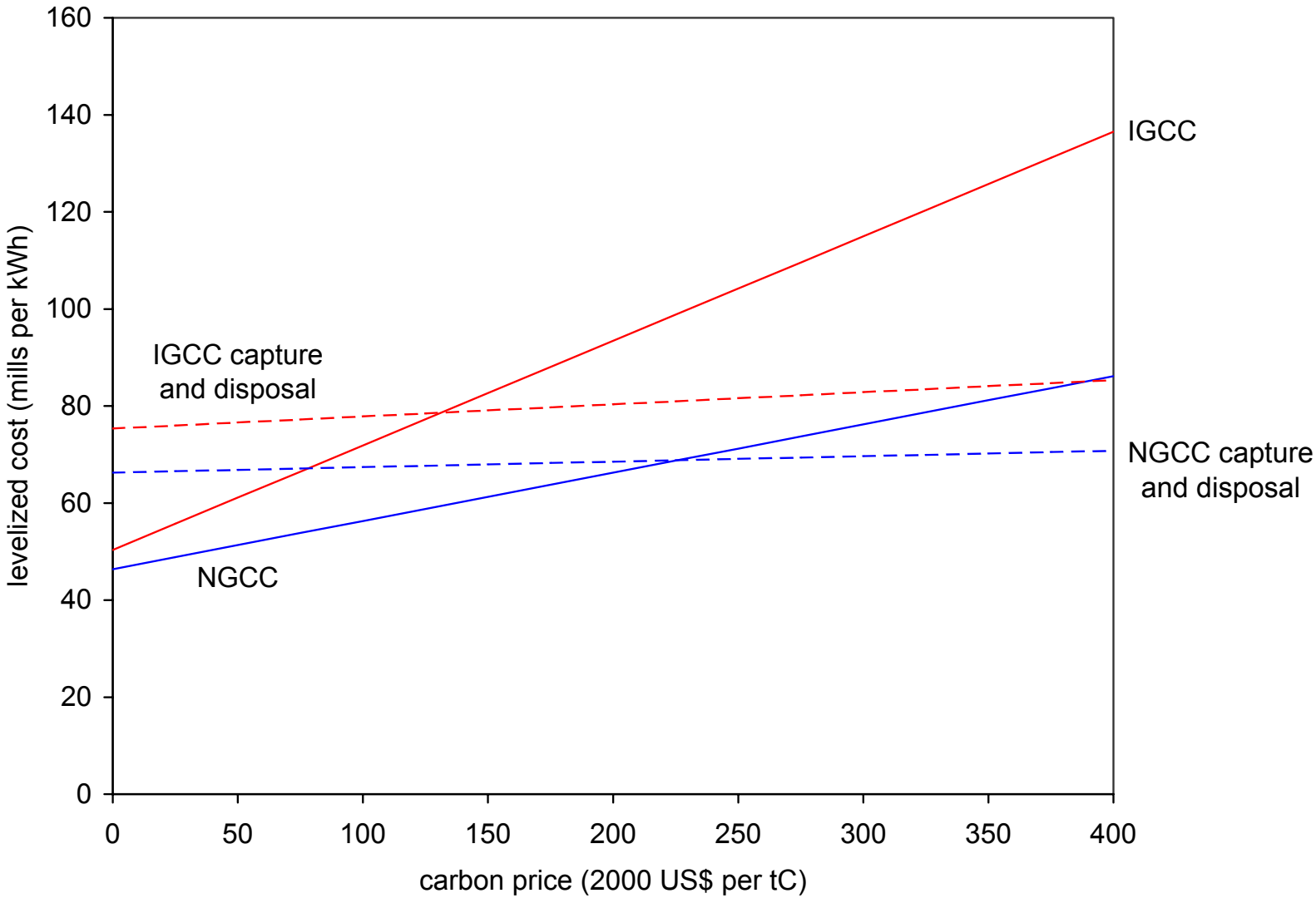
Second Generation Model

- SGM characteristics
  - Computable general equilibrium model of United States and other world regions
  - Five-year time steps from 1990 through 2050
  - Capital stocks are industry specific with a new vintage for each model time step
- New version allows for carbon capture and disposal from electric power
  - Engineering cost model for capture process from David and Herzog, 2000, “The Cost of Carbon Capture,” Proceedings of the Fifth International Conference on Greenhouse Gas Control Technologies
  - Constant cost of carbon disposal ($40 per tC)
- Following analysis focuses on United States

Marginal abatement cost curves for carbon emissions from the U.S. energy system using PNNL Second Generation Model



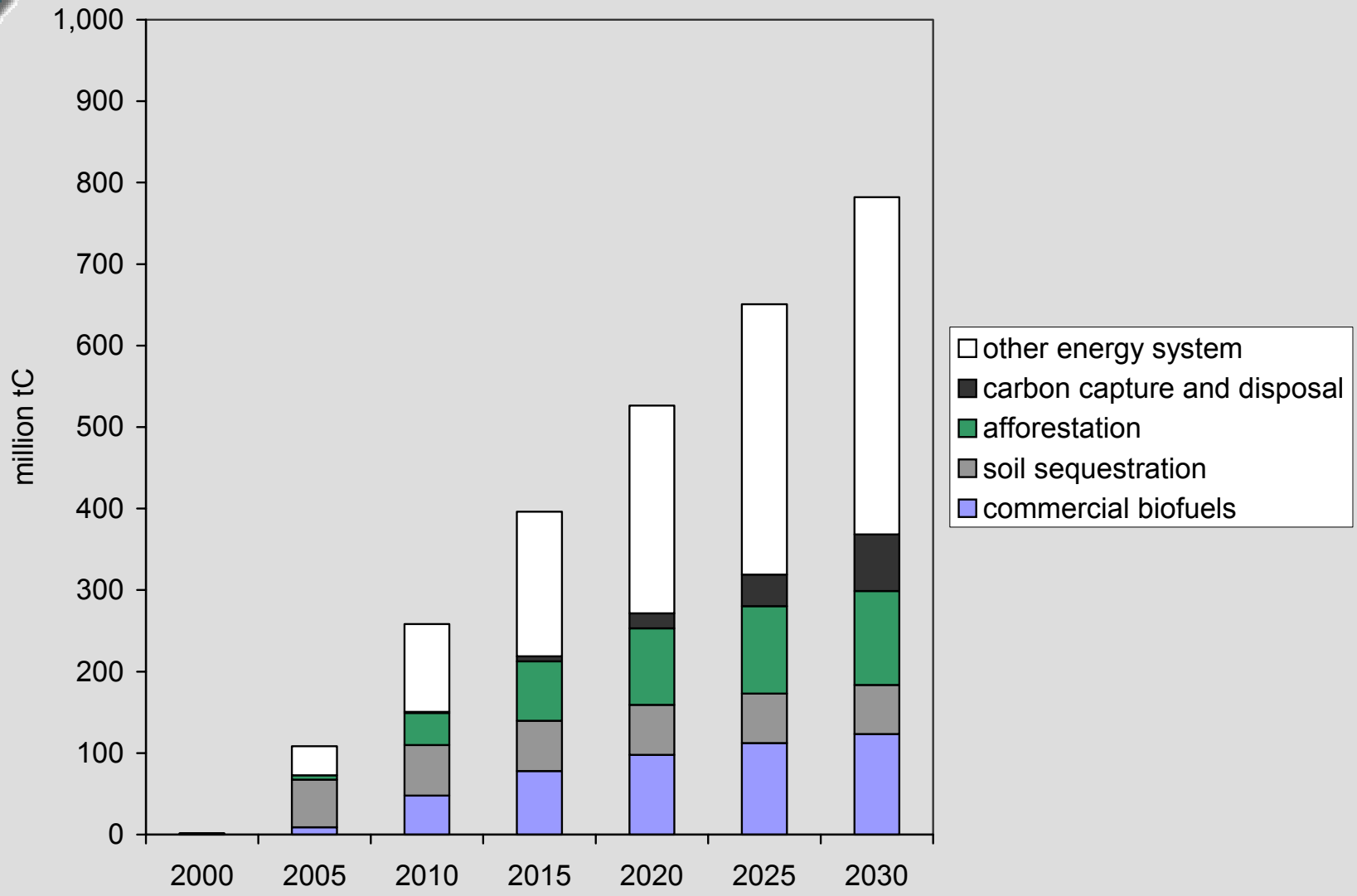
Levelized Cost of Electricity as a Function of Carbon Price



Emissions Scenario #1

- Hypothetical Target: net carbon emissions remain at year 2000 levels
- Flexibility
  - Terrestrial options used as offsets
  - Carbon capture and disposal from electric power available in 2010 and later
- Limitations on flexibility in this scenario
  - No purchases of foreign emissions rights
  - Cost for soil sequestration and afforestation increased 30% to cover transactions costs
  - Options for non-CO_2 gases not considered

Composition of U.S. Emissions Reductions (remain at year 2000 emissions)



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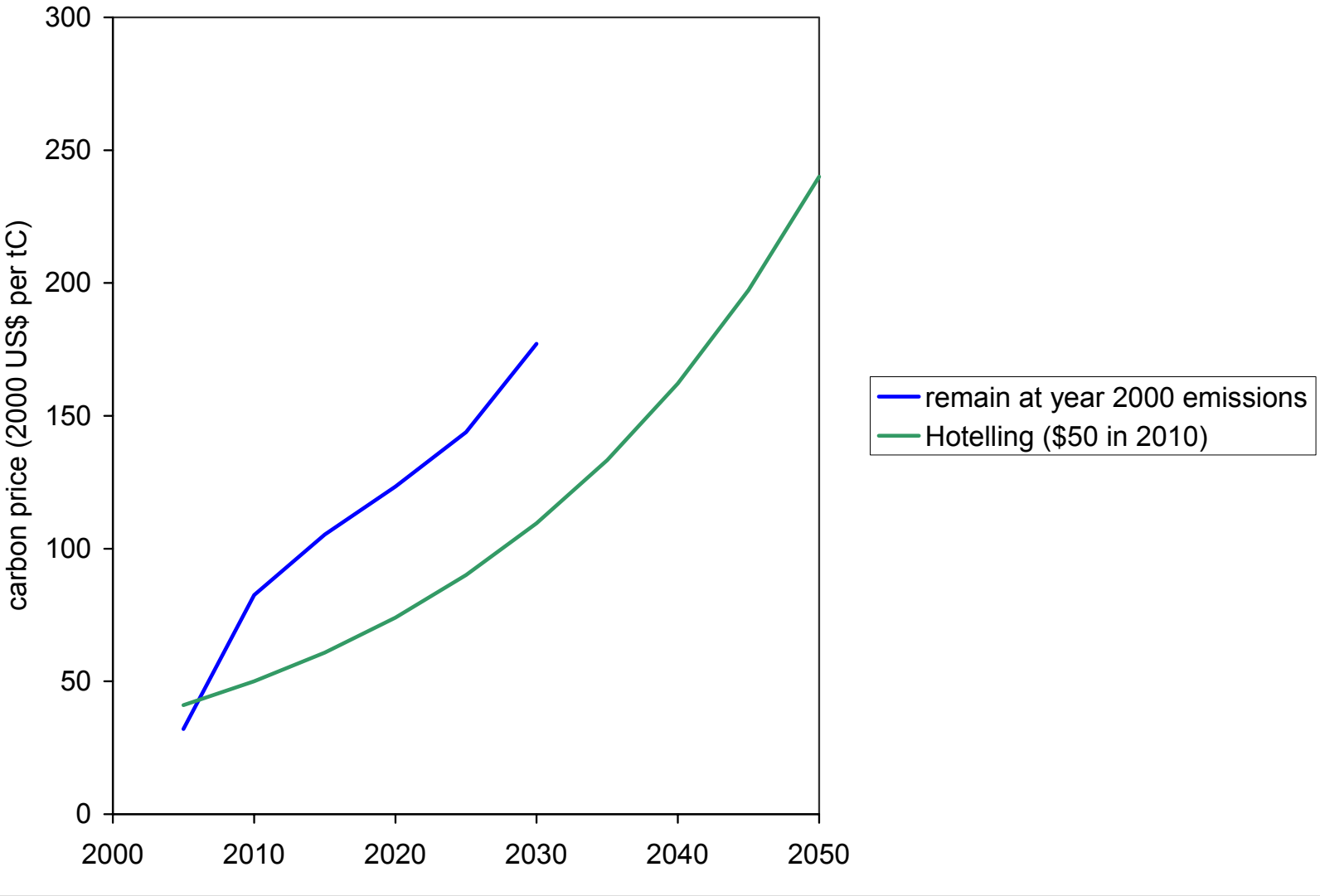
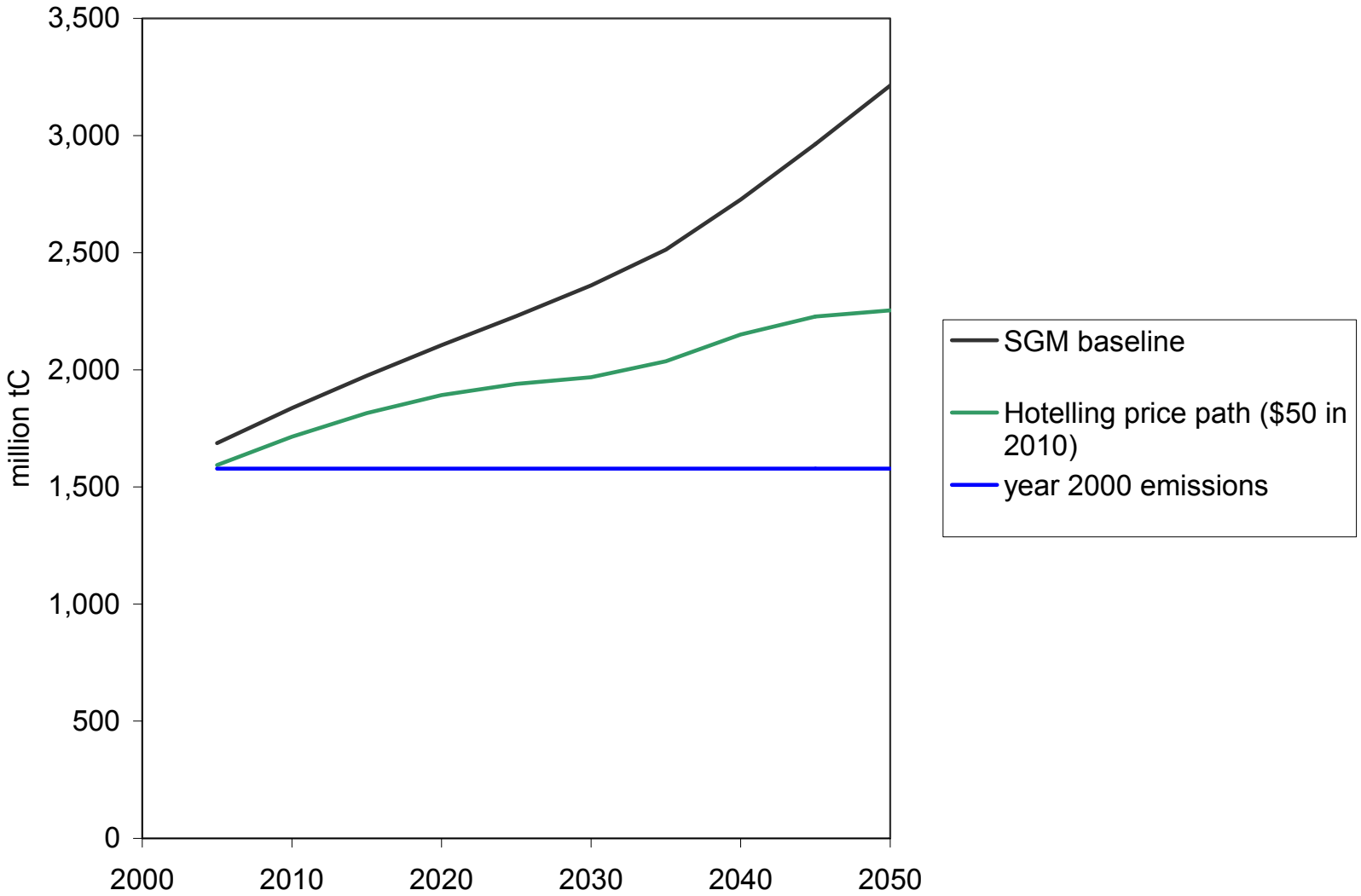
Emissions Scenario #2

- Hotelling carbon price path
  - Carbon price equals $50 per tC in year 2010
  - Carbon price increases at 4% per year, reaching $240 per tC in year 2050
- Same flexibility options as Scenario #1

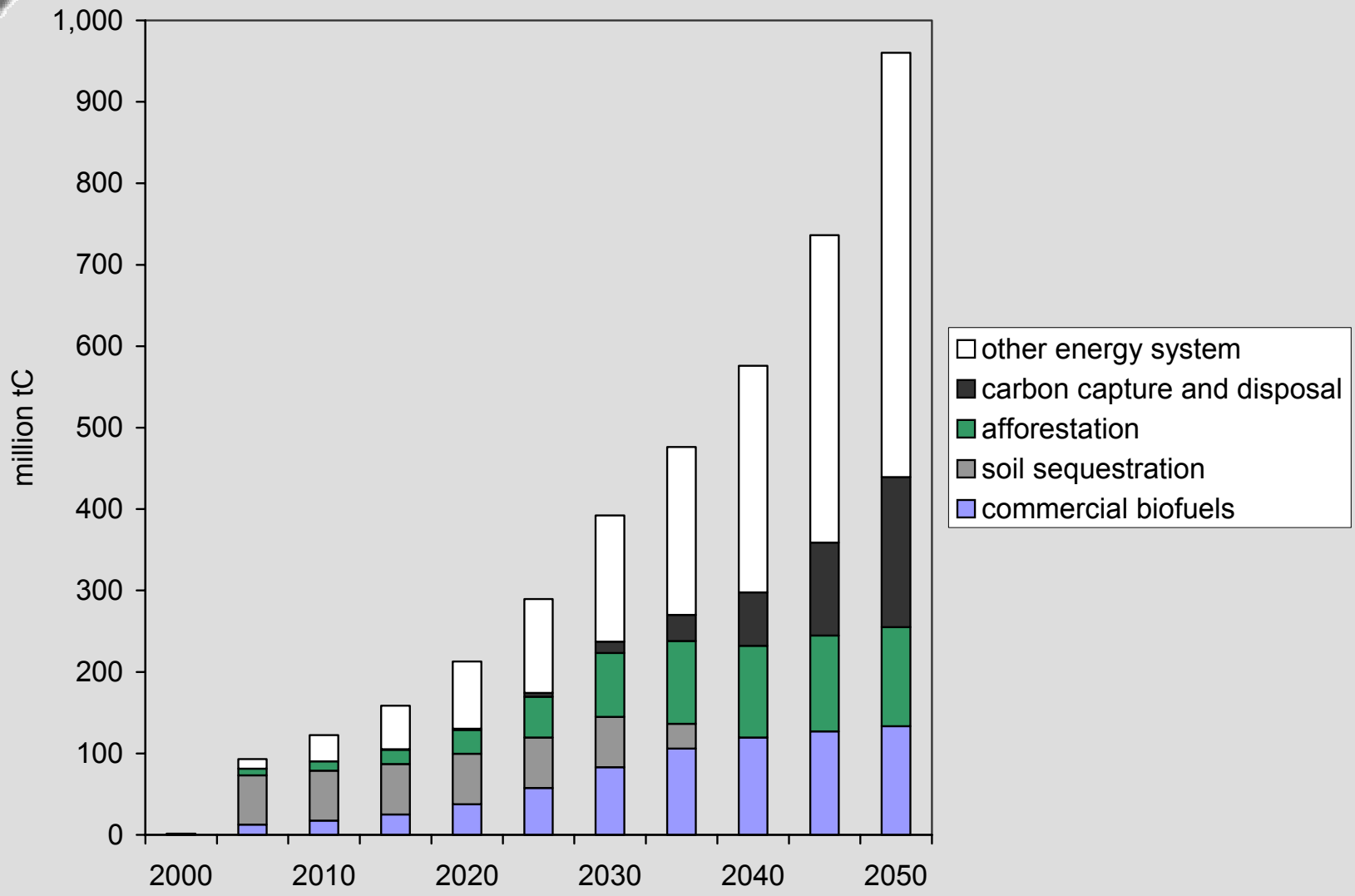
Carbon Prices in Two Hypothetical U.S. Emissions Scenarios



Net U.S. Carbon Emissions by Scenario



Composition of U.S. Emissions Reductions (Hotelling carbon price path)



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Conclusions

- It is possible for top-down economic models to accurately portray mitigation options from sector-specific models such as ASMGHG or from engineering cost models
- Contributions from agricultural mitigation options
  - Significant contribution to emissions reductions
  - Terrestrial options must be considered as a group and not in isolation
- Modeling challenges
  - Represent dynamics of saturation in marginal abatement cost curves
  - Demand for biofuels